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REVIEW OF CURRENT IN-SERVICE SMOKE MASK, EMERGENCY OXYGEN AND QUICK-DON ASSEMBLIES FOR CANADIAN FORCES AIRCRAFT

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ABSTRACT

Canadian Forces transport and maritime aircraft (both pressurized and non-pressurized) have been equipped with oxygen and smoke protective equipment from "off-the-shelf" items or on an as required basis. As a result, equipment and the protection provided is inconsistent and not standard between aircraft and between individual crew stations.

Current in service equipment and user opinion have been reviewed and specifications conforming to the physiological requirements and international standards have been established. Where analysis indicates insufficient or lack of adequate protection, recommendations have been made for either additional equipment or replacement.

LIST OF ABBREVIATIONS

CAA	-	Civil Aviation Authority, United Kingdom
CF	-	Canadian Forces
CFTOs	-	Canadian Forces Technical Orders
DAS Eng	-	Director of Aerospace Support Engineering
DCIEM	-	Defence and Civil Institute of Environmental Medicine
EWO	-	Electronic Warfare Officer
FAA	-	Federal Aviation Administration, United States
Flt Eng	-	Flight Engineer
Nav	-	Navigator
Obs	-	Observer
RAF	-	Royal Air Force
UCR	-	Unsatisfactory Condition Report
USAF	-	United States Air Force
USN	-	United States Navy

INTRODUCTION

Emergency oxygen masks and smoke protective equipment are used in Canadian Forces (CF) maritime and transport aircraft primarily for protection against hypoxia (in the event of cabin decompression or intentional unpressurized flight above 10,000 feet); secondly to protect from smoke or fumes in the cockpit or cabin; and finally for the treatment of in-flight physiological conditions such as hyperventilation and decompression sickness. There are thirteen individual equipment items or systems documented in CF Technical Orders (CFTOs), eleven of which are currently in use. Standardization and commonality of equipment does not exist and, in some cases, there is inadequate protection. Furthermore the CF does not have any specifications laid down as to the requirement. The Director of Aerospace Support Engineering (DAS Eng) tasked the Defence and Civil Institute of Environmental Medicine (DCIEM) to evaluate the emergency oxygen equipment in CF aircraft, develop specifications and recommend standardization and improvements.

METHOD

The evaluation of CF emergency oxygen equipment involved the following activities:

a. DAS Eng and user Squadrons were requested to provide information so that emergency oxygen equipment currently in use could be catalogued with respect to aircraft type and locations within the aircraft.

b. Unsatisfactory Condition Reports (UCRs) were reviewed and a survey of squadrons was conducted to determine user opinion with respect to emergency oxygen equipment suitability and to identify equipment deficiency. The survey encouraged suggestions of more appropriate equipment, if known.

c. DAS Eng was consulted to identify operational requirements for emergency oxygen equipment.

d. Two leading manufacturers in aviation oxygen systems were consulted to obtain information on state-of-the-art equipment.

e. International agencies (RAF, USN, USAF, FAA, CAA and commercial air lines) were consulted for mask requirements and regulations.

DESCRIPTION OF EQUIPMENT

General

Emergency oxygen equipment used in CF maritime and transport aircraft are stowed in the aircraft rather than being issued on a personal basis. The equipment includes masks, smoke goggles and portable assemblies. For ease of comparison, the masks are categorized in this report as quick donn, non-quick donn or drop down. All CF emergency oxygen equipment is required to satisfy Military Specifications (6, 7) or Federal Aviation Administration

(FAA) Aerospace Standards (3, 4), which address materiel, construction and performance characteristics.

Quick Donn Masks

A quick donn mask incorporates a suspension system which enables donning within five seconds using only one hand (4). The flow of oxygen is controlled by a regulator. The CF uses two masks in this category:

a. Sierra High Profile (NSN 1660-21-860-4062) - is comprised of a silicone rubber oronasal face piece, spring-loaded suspension harness, hard shell, microphone, inspiration/expiration valve, vent valve and oxygen supply hose. The flow of oxygen is controlled by either panel or mask mounted regulator. The face piece is produced in one size which fits all aircrew. The suspension is designed for donning over a communications headset. The vent valve provides goggle defogging when opened and regulator set to EMERGENCY. The hose incorporates a push/pull warning type connector. The mask assembly is donned by positioning the harness over the back of the head, pulling the mask forward (against the suspension spring force) and positioning the face piece.

b. Puritan Bennett Zep Aero (NSN 1660-21-860-4063) - is comprised of an oronasal face piece (hardshell), single band suspension, fibre hardshell, microphone, inspiration/expiration valve, and oxygen supply hose. Oxygen flow is controlled by an external regulator. The face piece has a vinyl covered foam filled edge cushion for fitting, comfort and face seal. The hard shell is produced in one size which fits all aircrew. The suspension is attached to the face piece by two elastic straps and incorporates two moulded plastic arms to facilitate donning. It is designed for donning over a communications headset. The hose connector is either a push/pull warning or threaded gland type. The mask assembly is donned by positioning the arms in the ready position so as to stretch the elastic retention straps, placing the suspension band behind the head, positioning the face piece and moving the arms to the donned position.

Non-Quick Donn Masks

A non-quick donn mask requires adjustment and hence takes more than five seconds to donn. The flow of oxygen is controlled by a regulator. There are also two masks in this category:

a. The A13A (Mask: NSN 1660-21-846-6443; Yoke: NSN 1660-21-875-8636 and Harness: NSN 1660-21-848-9085) - comprises a silicone rubber oronasal face piece, yoke suspension, Y-shaped hardshell, Sierra head harness, microphone, air inspiration and expiration valves and oxygen supply hose. The suspension has two adjustable straps which attach to the harness by pull-the-dot fasteners. The harness has two crescent-shaped ear pieces which are connected by five adjustable straps. The hose connector is a push/pull warning type. The mask is donned by placing the

harness over the back of the head, pulling the mask assembly into position over the face and adjusting first the yoke straps and then the harness straps to fit.

b. The Scott Full Face (NSN 1660-00-816-0410 or 1660-00-330-3900) - is comprised of a moulded rubber shell, harness, full face plastic lens, microphone, inspiration and expiration valves and oxygen supply hose. The harness consists of six moulded rubber straps which connects to the shell by means of metal buckles. The hose connector is either a push/pull warning or threaded gland type. The mask is donned by pulling the shell and harness over the head and adjusting the straps for proper fit.

Drop Down Masks (Boeing P/N C7040 and Falcon, P/N 2M 529-1)

A drop down mask is automatically released from its stowed position by an altitude sensing mechanism. It automatically provides a non-regulated constant flow of oxygen that is activated by a sharp pull on the oxygen hose. Masks in this category are used in the Falcon and Boeing aircraft. They are similar, comprising a conical or cylindrical shaped rubber oronasal face piece, plastic accumulator bag, elastic headband, oxygen, ambient inhalation/exhalation and relief valves. They are donned by placing the elastic band over the back of the head and positioning the mask on the face.

Smoke Goggles

Goggles provide eye protection against smoke and fumes. There are two types:

a. The Sierra (P/N 322-01) - has rounded (bug-eyed) clear plastic lenses with foam rubber edge and rubber headband. They are used with the Sierra High Profile mask.

b. The Industrial (NSN 4240-21-888-9667) - has a flat plastic lens, soft plastic shell and elastic head band. It is issued with the Puritan Bennett Zep Aero mask.

Portable Assemblies

A portable assembly can be carried and used by the crew members anywhere in the aircraft or, if it is necessary, to exit the aircraft. There are six types of portable assemblies:

a. MB-1 Assembly (NSN 1660-00-816-0401 or 1660-00-330-30\900 and 1660-21-811-0947) - consist of the Scott full face mask, a pressure demand regulator and a low pressure (450 psi) cylinder. Oxygen flow duration is twenty minutes.

b. MA-1 Assembly - is the same as the MB-1 except that it uses the A13A vice full face mask.

c. The Aviox - consists of a drop-down mask and chlorate candle solid state oxygen generating canister (17). Oxygen flow is continuous, and its duration is twenty minutes.

d. Scott Model 5500 - consists of a disposable or non-disposable mask, constant flow regulator and high pressure (1800 psi) cylinder. The cylinder has two outlets, enabling low flow (2 litres/min.) or high flow (4 litres/min.). Flow duration is between two and four hours, depending upon outlet selection.

e. Scott Model 5600 - consists of the Scott full face mask, a demand regulator and a high pressure (1800 psi) cylinder. Oxygen flow duration exceeds two hours.

f. Scott Dash 7 Model - consists of the Sierra High Profile mask, a demand regulator and a high pressure (1800 psi) cylinder. Oxygen flow duration exceeds two hours.

CATALOGUE OF EQUIPMENT IN AIRCRAFT

Primary equipment for respiratory protection used in CF maritime/transport aircraft is shown in Table 1, and secondary (portable) equipment is shown in Table 2. Protective equipment is available at all crew positions either in the form of a mask or portable assembly, and sometimes both. However, the type of respiratory protective equipment provided varies between the different crew positions of some aircraft types (i.e. CC117, CC132, CP140), and between different aircraft types for each of the specified crew positions. It is noted that portable assemblies are usually used as secondary systems but are sometimes used as the primary system, and that the number and location of portables are inconsistent between squadrons flying the same type of aircraft.

Eye protection equipment used in CF maritime/transport aircraft is shown in Table 3. Similar variations exist between aircraft types and between specified crew positions as for the respiratory protection equipment. In addition, some crew positions and, in fact, some entire aircraft (i.e. CC129, CC138) have no such equipment at all.

Only one aircraft (CC130) provides both mask with goggles and a portable assembly for all aircrew, hence primary and secondary systems for both types of protection. This complete and consistent protection was the result of UCR action.

AIRCREW OPINION

General

The aircrew generally responded with negative comments towards the equipment installed for their use. The majority of crew members requested a quick donning system with compatible eye protection. Positive comments were received for the Sierra High Profile mask and Sierra Smoke Goggle. They considered the protection provided to be adequate but felt the system was uncomfortable when worn for extended periods. A modification to the tension spring in the head harness suspension could reduce this discomfort and provide for harness size adjustment.

Oxygen Masks and Smoke Goggles

The Puritan Bennett Zeo Aro mask and industrial type flat plastic goggles are considered by the aircrew to be totally unsatisfactory for fit, donning and smoke protection, as indicated by UCR action.

Aircrew using the full face mask stated that while respiratory tract and eye protection are adequate the system has three deficiencies:

a. it is a non-quick donn type and requires two hands to donn;

b. it is difficult to perform valsalva manoeuvres with the mask on;

c. the optical face piece is susceptible to fogging.

The A13A mask does not incorporate eye protection, is not quick donning and the use of one medium size creates a fitting problem.

The drop down mask (passenger type) was disliked because of the uncontrolled constant flow, the lack of eye protection and the absence of communications.

Portable Assemblies

Comments on portable assemblies were made by Aurora and Falcon aircrew only. Falcon Flight Engineers requested a full face mask to replace the A13A, which lacks eye protection. Aurora crews want eye protection (goggles) with the Aviox generators, additional portables (MB-1) to be carried and an increase in the twenty minute duration of the Aviox generator (considered inadequate when unpressurized flight at high altitude must be maintained in order to conserve fuel).

Communications

Microphones are an integral part of most oxygen masks, and aircrew frequently expressed their concern about either loss or even short interruption of communications in an emergency where oxygen masks are required. They consider it to be an additional complication. Some aircraft have switches for changing from boom to mask microphone, and others require disconnection and reconnection of the microphone cord between oxygen mask and communications headset.

STATE-OF-THE-ART EQUIPMENT

The Eros system originally designed for the Concorde is made in France and distributed in the US by Scott Aviation. This system has a mask mounted regulator and a pneumatic harness assembly, which is inflated for donning and deflated when positioned on the wearer. Additional special features, such as defogging vent and physiological protection up to 45,000 feet, are available on request from the manufacturer. This mask is installed in a large number of commercial aircraft including the Challenger, which has recently been procured by the CF.

The Sierra High Profile mask, with or without defogging vents and mask-mounted regulator, is considered by the CF aircrews (survey results) and commercial airlines as the best equipment currently available. It is distributed by Scott Aviation.

Puritan Bennett are marketing systems offering adjustable quick donn harnesses, defogging vents and mask mounted regulators. Commercial user opinion, represented by only one commercial airline, was dissatisfaction. The mask is basically unchanged from its predecessor, the Zep Aero.

OPERATIONAL REQUIREMENTS

No directives, quidelines, references in CFTOs or any other CF orders which state the type of mask or smoke protection required for specific aircraft type or operational role were found. CF orders and directives describe the physiological requirement for oxygen but do not specify donning time, method of donning or the requirement for communication. Therefore the US Navy (USN), US Air Force (USAF) Royal Air Force (RAF) and British Civil Aviation Authority (CAA) were consulted to determine if any such directives, quidelines or regulations exist or are documented pertaining to their area of operation.

The USN, USAF and RAF do have regulations specific to each type of aircraft. There are no general rules and regulations. However, all agree in principle with the CAA regulation of a quick donn requirement for pressurized aircraft in that the mask should be capable of being donned by one hand, and establish oxygen and provide communications within five seconds.

SUGGESTED STANDARDS

Requirements proposed for emergency protective equipment based on the findings of this study are:

a. each configuration should provide eye protection (ie. goggles);

b. each configuration should have the capability of providing communications;

c. each crew member of pressurized aircraft should be provided a quick donn oxygen mask which can be donned with one hand and provide oxygen flow and communications within five seconds;

d. each crew member of non-pressurized aircraft should be provided an oxygen mask which can provide oxygen flow and communications within fifteen seconds;

e. portable systems should not be used as the primary source of protection but should be used as a secondary source and when crew members are required to perform duties away from their station.

CONCLUSIONS

Existing configurations of equipment that satisfy the proposed standards are:

a. Sierra quick donn mask with or without the mask-mounted regulator and Sierra goggles;

b. Scott Full Face non-quick donn mask in non-pressurized aircraft;

c. MB-1 and Scott 5600 and Dash-7 Model portable assemblies with communications capabilities;

Other configurations that do not satisfy the proposed standards are:

a. Zep Aero quick-donn mask with Industrial goggles, which are difficult to donn, unstable and uncomfortable.

b. A13A non-quick donn mask, which does not provide eye protection;

c. Drop-down masks, which do not provide eye protection or communications;

d. Scott 5500 Model portable assembly, which does not provide eye protection or communications;

e. MA-1 portable assembly, which does not provide eye protection;

f. Aviox solid state generator, which does not provide eye protection or communications.

RECOMMENDATIONS

It is recommended that the proposed standards be used in the selection and introduction of new equipment, and that the following changes to existing equipment as indicated by these standards be considered:

a. Cosmopolitan - remove A13A mask and equip observer/navigator position with a Sierra High Profile mask and Sierra Goggles.

b. Buffalo - crew masks remain as is. Install one (1) additional MB-1 assembly.

c. Falcon - equip pilot, co-pilot, flight engineer and electronics warfare officer with Sierra High Profile mask and Sierra Goggles. Install one (1) additional MB-1 assembly.

d. Dakota - provide smoke goggles for all crew positions.

e. Hercules - remains as is.

f. Dash-7 - equip flight engineer and loadmaster with Sierra High Profile mask with mask-mounted regulator. Install one (1) additional MB-1 assembly.

g. Boeing - equip pilot, co-pilot, flight engineer, navigator and loadmaster with Sierra High Profile mask and Sierra Goggles.

h. Twin Otter - provide smoke goggles for all crew. Install two (2) MB-1 assemblies.

j. Aurora - equip co-pilot and flight engineer with Sierra High Profile mask and Sierra Goggles; provide 12 smoke goggles for cabin crew; install 3 additonal MB-1 assemblies; and provide 2 (vice current 1) Aviox candles at each crew station.

REFERENCES

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   d. C-22-207-000/MS-000
   e. C-22-208-000/MS-000
   f. C-22-209-000/MS-000
   g. C-22-210-000/MS-000
   h. C-22-213-000/MS-000
   j. C-12-140-000/MB-001

3. Aerospace Standard 8031, June 1980

4. Aerospace Standard 8026, March 1981

5. FAA Technical Service Order, February 1979

6. Military Specification Mil-M-6482

7. Military Specification Mil-M-19427

8. DCIEM Letter 3614H-10 (MLSD), 9 June 1982

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13. Civil Aviation Authority (UK), Joint Air Requirements 25.1447 and Air Navigation Order Schedule 5

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Table 1 - Primary Equipment Used for Respiratory Tract Protection by CF Aircrew in Maritime and Transport Aircraft

Aircraft	Crew Positions							
	Pilot	Co-Pilot	Flt Engr	Nav	Load Master	Other Eqpt	Other Qty	Other Crews
Cosmopolitan CC109	S	S	S	-	-	A	1	Obs
Buffalo CC115	F	F	F	F	-	-	-	-
Falcon CC117	2	2	P-LA	-	-	D	1	FWO
Dakota CC129	A	A	A	A	-	A	4	Cabin
Hercules CC130	S	S	S	S	S	-	-	-
Dash-7 CC132	S(R)	S(R)	P-LF	-	P-LF	-	-	-
Boeing CC137	Z	Z	Z	Z	Z	-	-	-
Twin Otter CC138	A	A	-	-	-	-	-	-
Aurora CP140	S	F	F	P-SS	-	P-SS	11	Cabin

Legend

A - A13A Mask, Yoke Suspension, Sierra Head Harness

D - Drop Down Mask, Passenger Type

F - Scott Full Face Mask, Fire Fighter Type

S - Sierra High Profile Mask

S(R) - Sierra High Profile Mask With Mask-Mounted Regulator

Z - Puritan Bennett Zep Aero Mask

P-LA - Portable Low Pressure with A13A Mask (MA-1)

P-LF - Portable Low Pressure With Scott Full Face Mask (MB-1)

P-SS - Portable Aviox Solid State Generator

Table 2 - Secondary Equipment (Portable) Used For Respiratory Tract Protection by CF Aircrew in Maritime and Transport Aircraft

Aircraft	Type	Quantity	Available to
Cosmopolitan (CC109)	P-LF	4	All
Buffalo (CC115)	P-LF	3	Cabin
Falcon (CC117)	P-LF	1	Cabin
Dakota (CC129)	P-LF	5	All
Hercules (CC130)	P-LF	5	All
Dash-7 (CC132)	P-LF P-HN	1 1	Cabin Flight Deck
Boeing (CC137)	P-HC P-HF	6 5	Cabin Cabin
Twin Otter (CC138)	-	-	-
Aurora (CP140)	P-LF	2	Cabin

Legend

P-HC - Portable High Pressure With Disposable/Non-Disposable Mask (Scott 5500)

P-HF - Portable High Pressure With Full Face Mask (Scott 5600)

P-HN - Portable High Pressure - No Mask (Scott Dash-7)

P-LF - Portable Low Pressure With Full Face Mask (MB-1)

Table 3 - Eye Protection Equipment Used by CF Aircrew in Maritime and Transport Aircraft

Aircraft Type	Crew Positions						
	Pilot	Co-Pilot	Flight Engr	Nav	Load Master	Other Type	Other Qty.
Cosmopolitan CC109	S	S	S	-	-	P-LF	4
Buffalo CC115	F	F	F	F	-	P-LF	3
Falcon CC117	I	I	None	-	-	P-LF	1
Dakota CC129	None	None	None	-	-	P-LF	5
Hercules CC130	S	S	S	S	S	P-LF	5
Dash-7 CC132	S	S	F	-	F	P-LF	1
Boeing CC137	I	I	I	I	I	P-HF	5
Twin Otter CC138	None	None	-	-	-	None	
Aurora CP140	S	F	F	None	-	P-LF	2

Legend

S - Sierra Goggle

F - Full Face Firefighter Type

I - Industrial Goggle, Flat Plastic

P-LF - Portable Low Pressure With Full Face Mask

P-HF - Portable High Pressure With Full Face Mask

POOR

QUALITY

ORIGINAL